CLAIMS

What is claimed is:

1. A method of correcting gradient non-linearities in MR imaging comprising:

acquiring MR data in motion in a presence of gradient non-linearities;

transforming the MR data acquired into an image domain;

applying a warping correction to the transformed MR data; and

correcting the warp-corrected MR data for the motion induced during MR data acquisition.

2. The method of claim 1 wherein the step of transforming the MR data includes transforming one portion of the MR data at a time into the image domain, applying the warping correction to that portion of the MR data, correcting that portion of the MR data for motion, and accumulating the motion corrected MR data in a final image.

3. The method of claim 1 wherein the step of acquiring MR data includes acquiring MR data affected by a variation of the gradient non-linearities.

4. The method of claim 1 wherein the step of acquiring MR data in motion includes at least one of a scanning object moving with respect to a magnet, an object moving with respect to a gradient coil, a magnet moving with respect to an object, a gradient coil moving with respect to an object, a gradient coil and magnet moving with respect to an object, a gradient coil and object moving with respect to a magnet, a magnet and object moving with respect to a gradient coil, and a moving magnet, gradient coil, and object.

5. The method of claim 1 wherein the step of transforming MR data includes Fourier transforming each data point, point by point.

6. The method of claim 1 wherein the step of transforming MR data includes Fourier transforming each k-space line of data to the image domain.

7. The method of claim 2 wherein the step of correcting motion includes shifting the MR data by a pixel offset and the step of accumulating includes adding the MR data to any previous MR data corrected to form an image with corrected gradient non-linearity.

8. The method of claim 1 wherein the motion is induced by a moving table with respect to a bore of a magnet.

9. The method of claim 8 wherein the step of acquiring MR data includes acquiring MR data that is frequency encoded in a direction of motion and the step of transforming MR data includes applying a 1-D FFT and placing the 1-D FFT transformed data into an otherwise empty 2D/3D matrix and then applying further Fourier transform along any other directions.

10. The method of claim 1 wherein the warping correction is a precalculated gradient error calculation.

11. The method of claim 9 wherein the gradient error is calculated according to:

$$\hat{s}_{GW}(\vec{r}') = \sum_{n} f_{GW}\left(s\left(\vec{k}(t_n)\right)e^{j\vec{k}\cdot\vec{r}}\right)e^{-j\vec{k}\cdot\vec{p}(t_n)}$$

where $\sum_n s\left(\bar{k}\left(t_n\right)\right)e^{j\bar{k}\cdot\bar{r}}$ is a reconstruction summation over each k-space point, f_{GW} is a warp correction function, and $\bar{p}(t)$ is a position of a movable table as a function of time.

12. A method of correcting gradient non-linearities in moving table MR imaging comprising the steps of:

translating a patient on a movable table within a magnet;

acquiring MR data in a presence of gradient non-linearity;

reconstructing a portion of the MR data into an image;

correcting any warping in the portion of the MR data that is acquired in the presence of gradient non-linearity while in an image domain; and

shifting the MR data acquired and reconstructed to compensate for table motion.

13. The method of claim 12 further comprising determining an amount of MR data to process and wherein the step of shifting the MR data includes shifting the MR data a fixed amount for a given amount of MR data processed.

14. The method of claim 13 wherein the step of determining an amount of MR data to process is based on table speed, distance traveled, and an acquisition sequence applied.

15. The method of claim 13 further comprising the step of adding the MR data to previously acquired MR data for a given FOV.

16. The method of claim 12 wherein the amount of MR data to process at a given time is determined at least partially on table velocity so that the amount of MR data processed can be shifted an equal amount.

17. The method of claim 13 wherein a predefined distance is established, based on table velocity and an acquisition sequence applied, for determining the shifting needed to avoid image blurring.

18. The method of claim 17 wherein the predefined distance is given by:

$$D = {BW \cdot FOV_{freq} \cdot \tau} / {N_{freq}^2}$$

where BW is receiver bandwidth, FOV_{freq} is a frequency-encoding field-of-view, N_{freq} is a number of frequency encoding points, and τ is a time of travel calculated from the table velocity.

19. The method of claim 12 wherein the step of reconstructing includes first Fourier transforming in a direction of table motion, then applying a 2D/3D Fourier transform.

20. The method of claim 19 further comprising placing the first Fourier transformed MR data in an otherwise empty matrix to then apply the 2D/3D Fourier transform thereto.

21. The method of claim 12 wherein the step of correcting any warping is only performed on MR data that is acquired in the presence of gradient non-linearity.

22. The method of claim 12 wherein the step of correcting any warping is performed with a GradWarp function.

23. The method of claim 12 wherein the step of correcting any warping is performed with a pre-existing gradient error map.

24. The method of claim 12 further comprising the step of monitoring table motion while acquiring MR data.

25. The method of claim 12 wherein the MR data is processed by one of line-by-line and point-by-point.

26. An MR apparatus having gradient non-linearity compensation for moving objects comprising:

a magnetic resonance imaging system having a plurality of gradient coils positioned about a bore of a magnet to impress a polarizing magnetic field and an RF transceiver system and an RF switch controlled by a pulse module to transmit RF signals to an RF coil assembly to acquire MR images;

a movable table to translate an imaging object about the magnet; and

a computer programmed to:

translate the moving table through the bore of the magnet;

acquire MR data of an imaging object positioned on the moving table as the movable table is translated through the bore of the magnet;

process the MR data acquired by one of point-by-point and line-by-line;

perform a 1-D FT on the MR data in a direction of table motion;

perform at least one additional FT on the MR data;

apply a GradWrap function on the MR data; and

fill an image space with the MR data.

27. The apparatus of claim 26 wherein the computer is further programmed to correct the MR data for motion after application of the GradWarp function.

28. The apparatus of claim 26 wherein the image is filled by adding the MR data to build up an image after application of the GradWarp function.

29. The apparatus of claim 26 wherein the GradWarp function uses a predetermined error map of gradient non-linearities.

30. The apparatus of claim 26 wherein the computer is further programmed to determine an amount of MR data to process and shift the MR data a fixed amount for a given amount of MR data processed.

31. A computer program for compensating for gradient non-linearities in moving table MR imaging, the computer program comprising a set of instructions to cause a computer to:

move a patient table with respect to a gradient coil;

acquire a plurality of MR data points;

place at least one MR data point into a matrix sized based on a desired image dimension sought wherein a remainder of the matrix has zeros therein;

perform an FFT, a type of which is based on the desired image dimension sought, to each MR data point;

apply a GradWrap function to the MR data points;

correct each MR data point for patient table motion; and

add each MR data point to build up an image.

32. The computer program of claim 31 wherein the MR data acquired is affected by gradient variations.

33. The computer program of claim 31 wherein the step of correcting for patient table motion includes finding a pixel offset based on motion velocity and shifting the MR data point by the pixel offset.

34. The computer program of claim 31 wherein the GradWarp function uses a predetermined error map of gradient non-linearity coefficients.

35. The computer program of claim 31 wherein a gradient error is calculated according to:

$$\hat{s}_{GW}(\bar{r}') = \sum_n f_{GW}\left(s\left(\bar{k}(t_n)\right)e^{j\bar{k}\cdot\bar{r}}\right)e^{-j\bar{k}\cdot\bar{p}(t_n)}$$

where $\sum_n s\left(\bar{k}(t_n)\right)e^{j\bar{k}\cdot\bar{r}}$ is a reconstruction summation over each k-space point, f_{GW} is a warp correction function, and $\bar{p}(t)$ is a position of a movable table as a function of time.